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Abstract

INVESTIGATIONS CARRIED OUT WITH THE VVR-S RESEARCH REACTOR AT THE ATOMIC PHYSICS INSTITUTE, BUCHAREST

Horia Hulubei
Atomic Physics Institute, Bucharest, Romania

Certain aspects of the research carried out with the VVR-S reactor are discussed; we hope, in this way, to be able to contribute to discussions on the appropriate utilization of research reactors.

Our Institute has an enriched uranium, water-cooled and -moderated research reactor of 2000 kW rated capacity, which went critical in 1957. Not long after criticality we were able to undertake the most advanced type of research in reactor and nuclear physics possible with this kind of installation - research which in many cases has a direct bearing on the peaceful applications of nuclear energy in Romania.

The installations and equipment necessary for the research in question were constructed almost wholly with the Institute's own means. All kinds of choppers, various crystal spectrometers, time and amplitude analysers, simulators, radiospectroscopy and nuclear spectroscopy equipment, digital and analogue computers and a large complement of nuclear electronics installations and equipment, made available in this manner, have assisted our research projects and furthered the applications of atomic energy in Romania. A few examples are given by way of illustration. We have thus managed to fulfil one of the first requirements for the training of our specialists, of whom there are very few at the present time, and it therefore seemed appropriate to mention briefly this form of activity.

The capacity of the reactor has been reserved partly for the production of radioisotopes required in research and in practical applications.

About 300 curies are distributed regularly each year in the form of several dozen different isotopes and numerous labelled mineral and organic

substances. These are used on a continuing basis in biology, medicine, agriculture, the chemical and petroleum industries, the iron and steel industry, metallurgy, hydrology and prospecting. Mixed teams of technicians, chemists, physicists, electronics experts and engineers have created the installations and equipment needed both for the production of these isotopes and their practical utilization.

It is our conviction that a country with little experience in the nuclear field can, provided it has a research reactor of medium power, quickly train good specialists, awaken interest in this type of work and render considerable practical services by producing radioisotopes and using them in practical ways. This point is illustrated by examples.

At the start we had few experimental data on the reactor. A series of studies on transient operation and on the lattice enabled us to perfect certain techniques of use in reactor physics research, and to determine the parameters of the installation. Having acquired this experience, we succeeded in raising the power of the reactor from 2000 to 3500 kW, and by using what we call internal thermal columns we increased the thermal neutron flux, in certain regions of the core, by a factor of up to 3.7. These results facilitated the production of certain radioisotopes and were turned to good account in radiation chemistry, in studying the effects of radiation on matter and in certain types of reactor physics research. Other problems have been tackled with this reactor and a subcritical assembly coupled to the reactor's thermal column through a sinusoidal modulator. Using the frequency characteristic method, we obtained - in a more convenient manner - results at least as good as those provided by the pulsed source.

Quite detailed studies of reactor automation from start-up to operation at rated power, as well as investigations designed to ensure safety should the reactor exceed a certain power level, have also been undertaken.

Mention is also made of a series of investigations in neutron physics, ranging from measurement of total cross-sections by the time-of-flight method (for thermal and epithermal neutrons) to studies on the structure of solids, liquids and gases by elastic and inelastic scattering of thermal and cold neutrons. Differential cross-sections, $d^2\sigma/d\Omega\,dE$, are measured

with precision crystal spectrometers, monochromators, triaxial spectrometers and curved-slit choppers. With the exercise of some care one can obtain, despite the relatively small neutron flux and the background of epithermal and fast neutrons characteristic of this type of reactor, results of interest in connection with the contribution of molecular rotation and coherence to inelastic scattering, the variation of inelastic scattering as a function of temperature, narrow-angle scattering in ferromagnetic substances (near the Curie point), measurements of scattering length by the total reflection method, and so on.

Similarly, the paper reports a considerable body of research in such subjects as nuclear reactions, radiochemistry, radiation chemistry, nuclear materials and so on, with the results of which we have been well satisfied.

Certain studies in radiation chemistry have been carried out by means of more intense radiation fields produced by a setup that utilizes the hot rods of the reactor; these have enabled us to obtain, for example, fatty acids of great importance for the chemical industry by oxidation of certain paraffins irradiated in this manner.

Finally, considerable weight can and should be placed on the practical applications of nuclear energy; this has been done in Romania, and the subject is briefly discussed.

At the present time there are a great many medium-power research reactors in the world. By using them systematically countries can, with a minimum of financial outlay, create conditions favourable for the training of a basic cadre of atomic scientists and go some way towards utilizing nuclear energy on the scale required by modern life.

It is with these points in mind that Romanian experience is discussed in the paper.